HIGH COMMON-MODE VOLTAGE DIFFERENCE AMPLIFIER

FEATURES

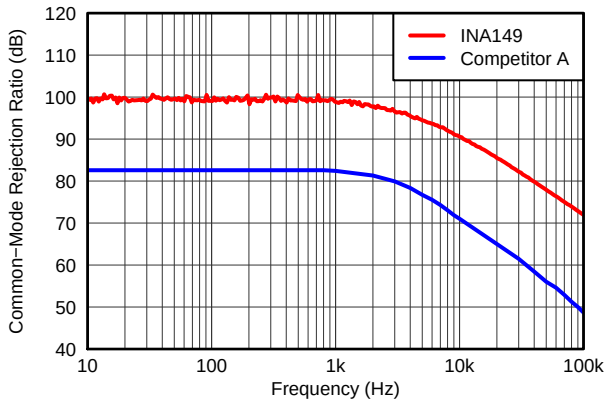
- **Common-Mode Voltage Range: ±275 V**
- **Minimum CMRR: 84 dB from –55°C to +125°C**
- **DC Specifications:**
  - **Maximum Offset Voltage: 3500 µV**
  - **Maximum Gain Error: 0.047%**
  - **Maximum Gain Nonlinearity: 0.001% FSR at 25°C**
- **AC Performance:**
  - **Bandwidth: 500 kHz**
  - **Typical Slew Rate: 5 V/µs**
- **Wide Supply Range: ±2.0 V to ±18 V**
  - **Maximum Quiescent Current: 1100 µA**
  - **Output Swing on ±15-V Supplies: ±13.5 V**
- **Input Protection:**
  - **Common-Mode: ±500 V**
  - **Differential: ±500 V**

APPLICATIONS

- **High-Voltage Current Sensing**
- **Battery Cell Voltage Monitoring**
- **Power-Supply Current Monitoring**
- **Motor Controls**
- **Replacement for Isolation Circuits**

SUPPORTS DEFENSE, AEROSPACE, AND MEDICAL APPLICATIONS

- **Controlled Baseline**
- **One Assembly/Test Site**
- **One Fabrication Site**
- **Available in Military (–55°C/125°C) Temperature Range**(1)
- **Extended Product Life Cycle**
- **Extended Product-Change Notification**
- **Product Traceability**



(1) Additional temperature ranges available - contact factory

DESCRIPTION

The INA149 is a precision unity-gain difference amplifier with a very high input common-mode voltage range. It is a single, monolithic device that consists of a precision op amp and an integrated thin-film resistor network. The INA149 can accurately measure small differential voltages in the presence of common-mode signals up to ±275 V. The INA149 inputs are protected from momentary common-mode or differential overloads of up to 500 V.

In many applications, where galvanic isolation in not required, the INA149 can replace isolation amplifiers. This ability can eliminate costly isolated input side power supplies and the associated ripple, noise, and quiescent current. The excellent 0.0005% nonlinearity and 500-kHz bandwidth of the INA149 are superior to those of conventional isolation amplifiers.

The INA149 is pin-compatible with the INA117 and INA148 type high common-mode voltage amplifiers and offers improved performance over both devices. The INA149 is available in the SOIC-8 package with operation specified over the military temperature range of –55°C to +125°C.

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION(1)

T_A	PACKAGE	ORDERABLE PART NUMBER	PACKAGE MARKING	VID NUMBER
-55°C to 125°C	SOIC-8 - D	INA149AMDREP	INA149AM	V62/12614-01XE

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or visit the device product folder at www.ti.com.

ABSOLUTE MAXIMUM RATINGS(1)

Over operating free-air temperature range, unless otherwise noted.

		INA149	UNIT
Supply voltage	(V+) – (V–)	40	V
Input voltage range	Continuous	300	V
Common-mode and differential, 10 s		500	V
Maximum Voltage on REF_A and REF_B		(V–) – 0.3 to (V+) + 0.3	V
Input current on any input pin(2)		10	mA
Output short-circuit current duration		Indefinite	
Operating temperature range		–55 to +125	°C
Storage temperature range		–65 to +150	°C
Junction temperature		+150	°C
ESD rating	Human body model (HBM)	1500	V
	Charged device model (CDM)	1000	V
	Machine model (MM)	100	V

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
(2) REF_A and REF_B are diode clamped to the power-supply rails. Signals applied to these pins that can swing more than 0.3 V beyond the supply rails should be limited to 10 mA or less.

THERMAL INFORMATION

THERMAL METRIC(1)		INA149 D (SOIC) 8 PINS	UNITS
θ_{JA}	Junction-to-ambient thermal resistance(2)	110	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance(3)	57	
θ_{JB}	Junction-to-board thermal resistance(4)	54	
ψ_{JT}	Junction-to-top characterization parameter(5)	11	
ψ_{JB}	Junction-to-board characterization parameter(6)	53	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance(7)	N/A	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.
(2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.
(3) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
(4) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.
(5) The junction-to-top characterization parameter, ψ_{JT}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA}, using a procedure described in JESD51-2a (sections 6 and 7).
(6) The junction-to-board characterization parameter, ψ_{JB}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA} , using a procedure described in JESD51-2a (sections 6 and 7).
(7) The junction-to-case (bottom) thermal resistance is obtained by simulating a cold plate test on the exposed (power) pad. No specific JEDEC standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

ELECTRICAL CHARACTERISTICS: V+ = +15 V and V– = –15 V

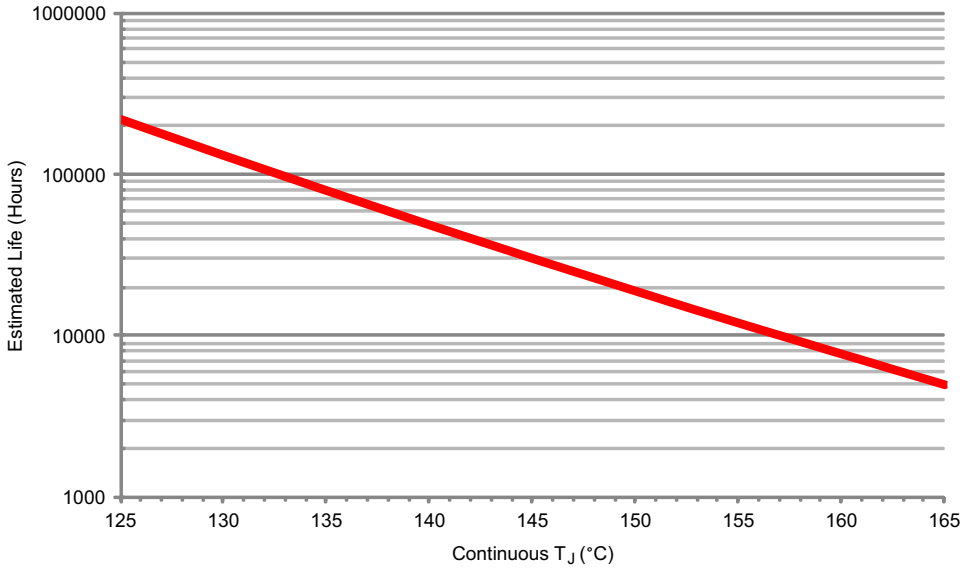
At T_A = +25°C, R_L = 2 kΩ connected to ground, and V_{CM} = REF_A = REF_B = GND, unless otherwise noted.

PARAMETER	TEST CONDITIONS	INA149			UNIT
		MIN	TYP	MAX	
GAIN					
Initial	V_{OUT} = ±10.0 V,		1		V/V
Gain error	V_{OUT} = ±10.0 V, T_A = –55°C to +125°C		±0.005	±0.047	%FSR
Gain	vs temperature, T_A = –55°C to +125°C		±1.5		ppm/°C
Nonlinearity			±0.0005	±0.001	%FSR
OFFSET VOLTAGE					
Initial offset	T_A = –55°C to +125°C		350	3500	µV
	vs temperature, T_A = –55°C to +125°C		2.5		µV/°C
	vs supply (PSRR), V_S = ±2 V to ±18 V, T_A = –55°C to +125°C	90	120		dB
INPUT					
Impedance	Differential		800		kΩ
	Common-mode		200		kΩ
Voltage range	Differential	–13.5		13.5	V
	Common-mode	–275		275	V
Common-mode rejection (CMRR)	At dc, V_{CM} = ±275 V, T_A = –55°C to +125°C	84	98		dB
	At ac, 500 Hz, V_{CM} = 500 V_{PP}		90		dB
	At ac, 1 kHz, V_{CM} = 500 V_{PP}		90		dB
OUTPUT					
Voltage range	T_A = –55°C to +125°C	–13.5		13.5	V
Short-circuit current			±25		mA
Capacitive load drive	No sustained oscillations		10		nF
OUTPUT NOISE VOLTAGE					
0.01 Hz to 10 Hz			20		μV_{PP}
10 kHz			550		nV/√Hz
DYNAMIC RESPONSE					
Small-signal bandwidth			500		kHz
Slew rate	V_{OUT} = ±10-V step, T_A = –55°C to +125°C	1.7	5		V/µs
Full-power bandwidth	V_{OUT} = 20 V_{PP}		32		kHz
Settling time	0.01%, V_{OUT} = 10-V step		7		µs
POWER SUPPLY					
Voltage range		±2		±18	V
Quiescent current	V_S = ±18 V, V_{OUT} = 0 V		810	950	µA
	vs temperature, T_A = –55°C to +125°C		0.95	1.1	mA
TEMPERATURE RANGE					
Specified		–55		+125	°C
Operating		–55		+125	°C
Storage		–65		+150	°C

ELECTRICAL CHARACTERISTICS: V+ = 5 V and V– = 0 V

At T_A = +25°C, R_L = 2 kΩ connected to 2.5 V, and V_{CM}= REF_A = REF_B = 2.5 V, unless otherwise noted.

PARAMETER	TEST CONDITIONS	INA149			UNIT
		MIN	TYP	MAX	
GAIN					
Initial	V_{OUT} = 1.5 V to 3.5 V		1		V/V
Gain error	V_{OUT} = 1.5 V to 3.5 V		±0.005		%FSR
Gain	vs temperature, T_A = –55°C to +125°C		±1.5		ppm/°C
Nonlinearity			±0.0005		%FSR
OFFSET VOLTAGE					
Initial offset			350		µV
	vs temperature, T_A = –55°C to +125°C		3		µV/°C
	vs supply (PSRR), V_S = 4 V to 5 V		120		dB
INPUT					
Impedance	Differential		800		kΩ
	Common-mode		200		kΩ
	Common-mode	–20		25	V
Common-mode rejection	At dc, V_{CM} = –20 V to 25 V		100		dB
	vs temperature, T_A = –55°C to +125°C, at dc		100		dB
	At ac, 500 Hz, V_{CM} = 49 V_{PP}		100		dB
	At ac, 1 kHz, V_{CM} = 49 V_{PP}		90		dB
OUTPUT					
Voltage range		1.7		3.4	V
Short-circuit current			±15		mA
Capacitive load drive	No sustained oscillations		10		nF
OUTPUT NOISE VOLTAGE					
0.01 Hz to 10 Hz			20		μV_{PP}
10 kHz			550		$nV/\sqrt{Hz}$
DYNAMIC RESPONSE					
Small-signal bandwidth			500		kHz
Slew rate	V_{OUT} = 2 V_{PP} step		5		V/µs
Full-power bandwidth	V_{OUT} = 2 V_{PP}		32		kHz
Settling time	0.01%, V_{OUT} = 2 V_{PP} step		7		µs
POWER SUPPLY					
Voltage range			5		V
Quiescent current	V_S = 5 V		810		µA
	vs temperature, T_A = –55°C to +125°C		1		mA



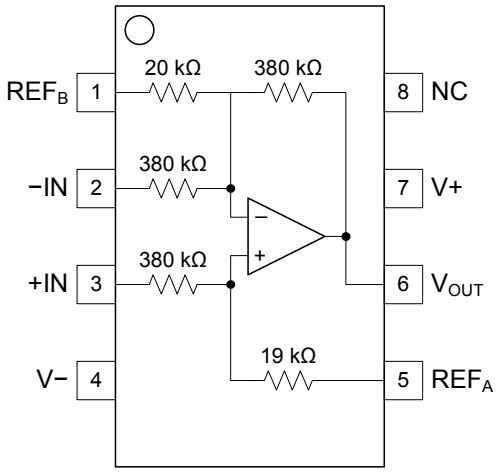
A. See datasheet for absolute maximum and minimum recommended operating conditions.

B. Silicon operating life design goal is 10 years at 105°C junction temperature (does not include package interconnect life).

Figure 1. INA149 Wirebond Life Derating Chart

PIN CONFIGURATION

D PACKAGE
SOIC-8
(TOP VIEW)



PIN DESCRIPTIONS

NAME	NO.	DESCRIPTION
–IN	2	Inverting input
+IN	3	Noninverting input
NC	8	No internal connection
REF_A	5	Reference input
REF_B	1	Reference input
V–	4	Negative power supply
V+	7	Positive power supply(1)
V_{OUT}	6	Output

(1) In this document, (V+) – (V–) is referred to as V_S.

TYPICAL CHARACTERISTICS

At T_A = +25°C, R_L = 2 kΩ connected to ground, and V_S = ±15 V, unless otherwise noted.

CMRR vs FREQUENCY

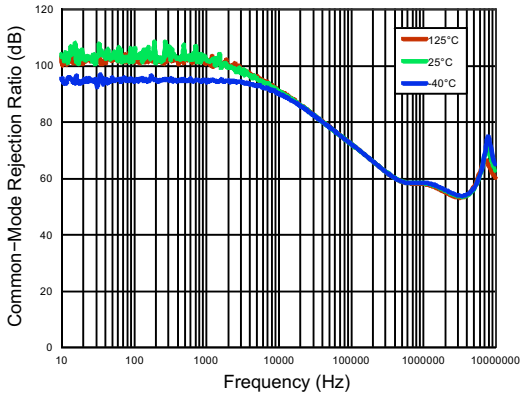


Figure 2.

COMMON-MODE REJECTION

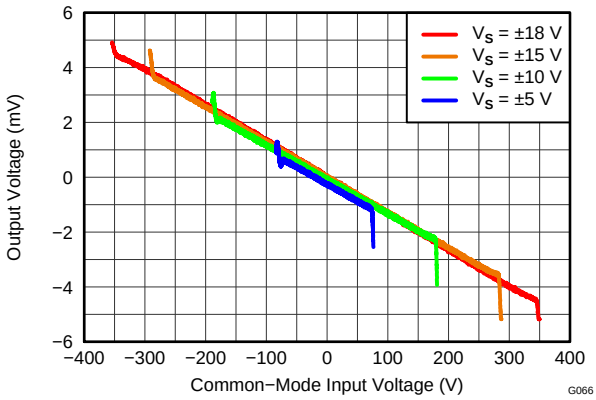


Figure 3.

COMMON-MODE OPERATING RANGE vs POWER-SUPPLY VOLTAGE

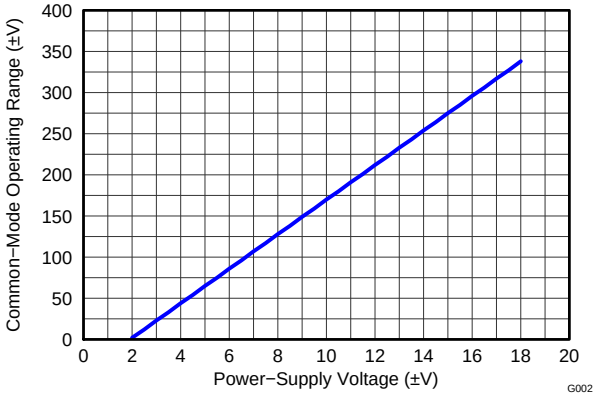


Figure 4.

TYPICAL GAIN ERROR FOR R_L = 10 kΩ (Curves Offset for Clarity)

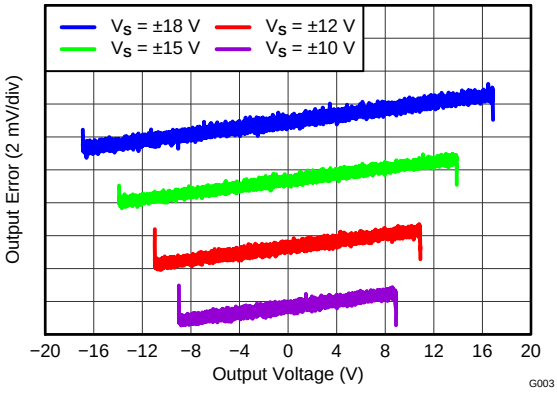


Figure 5.

TYPICAL GAIN ERROR FOR R_L = 2 kΩ (Curves Offset for Clarity)

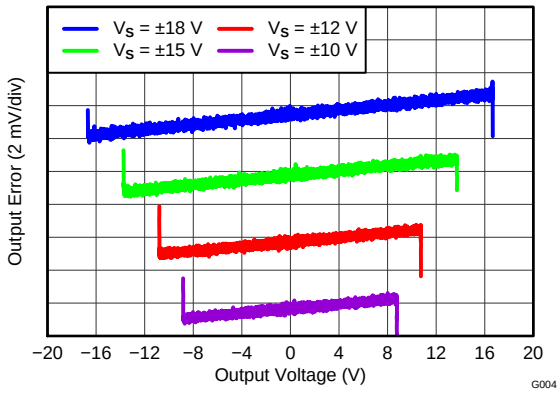


Figure 6.

TYPICAL GAIN ERROR FOR R_L = 1 kΩ (Curves Offset for Clarity)

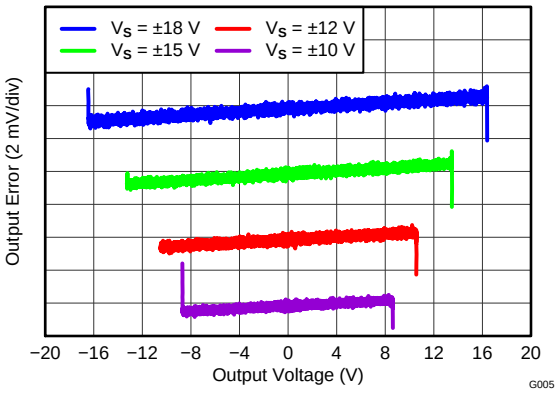


Figure 7.

TYPICAL CHARACTERISTICS (continued)

At T_A = +25°C, R_L = 2 kΩ connected to ground, and V_S = ±15 V, unless otherwise noted.

TYPICAL GAIN ERROR FOR LOW SUPPLY VOLTAGES (Curves Offset for Clarity)

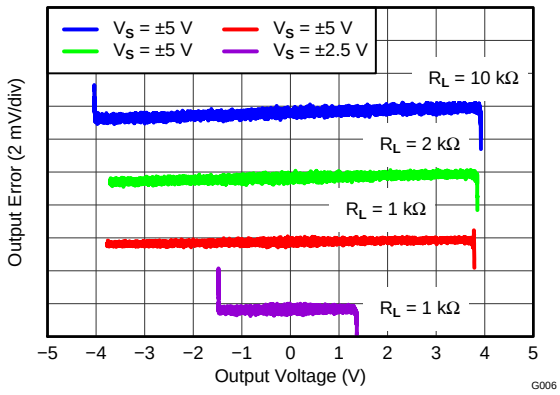


Figure 8.

GAIN NONLINEARITY

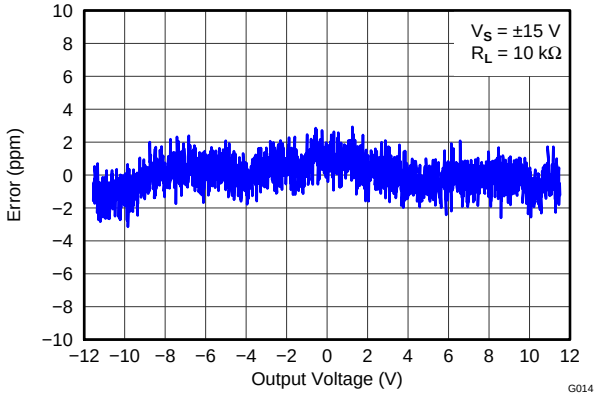


Figure 9.

GAIN NONLINEARITY

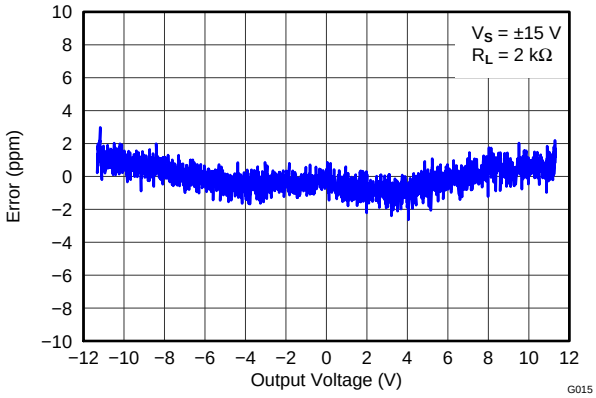


Figure 10.

GAIN NONLINEARITY

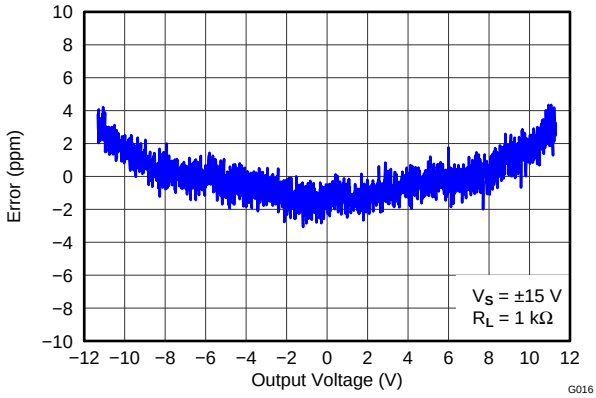


Figure 11.

GAIN NONLINEARITY

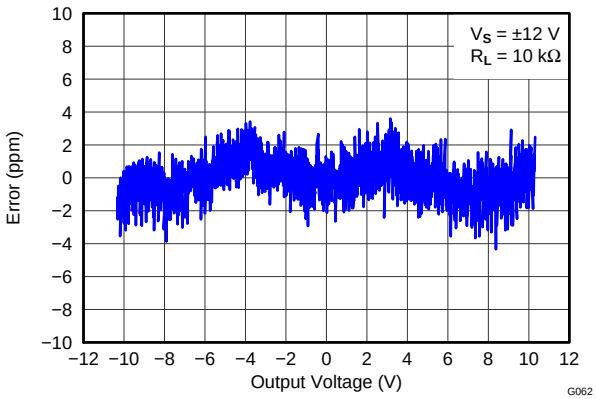


Figure 12.

OUTPUT VOLTAGE vs LOAD CURRENT

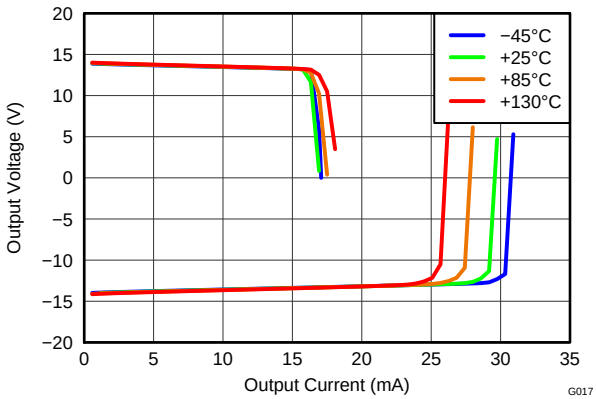


Figure 13.

TYPICAL CHARACTERISTICS (continued)

At T_A = +25°C, R_L = 2 kΩ connected to ground, and V_S = ±15 V, unless otherwise noted.

GAIN vs FREQUENCY

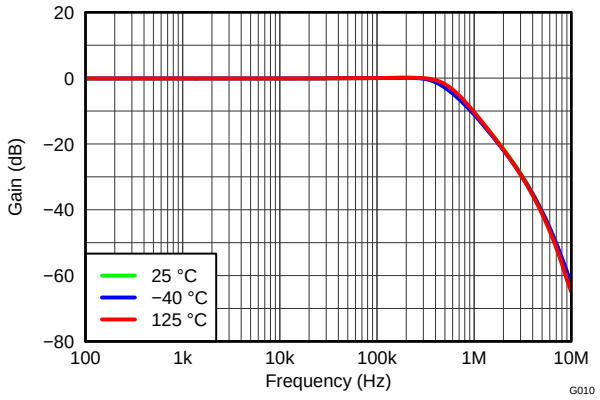


Figure 14.

NOISE SPECTRAL DENSITY vs FREQUENCY

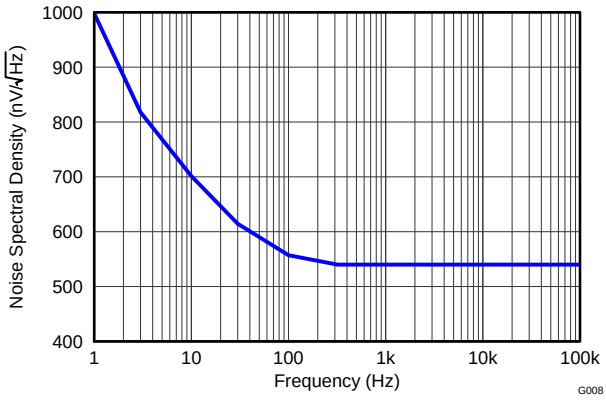


Figure 15.

0.01 Hz TO 10 Hz NOISE

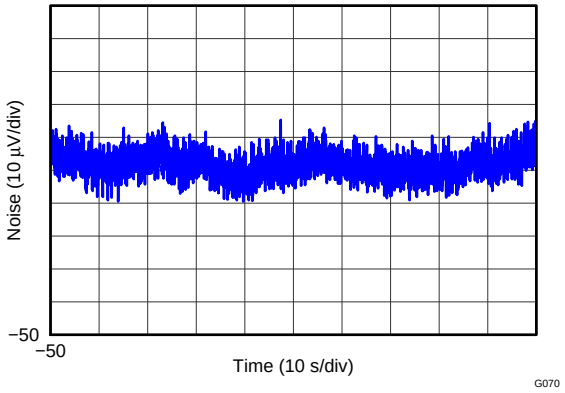


Figure 16.

POSITIVE PSRR vs FREQUENCY

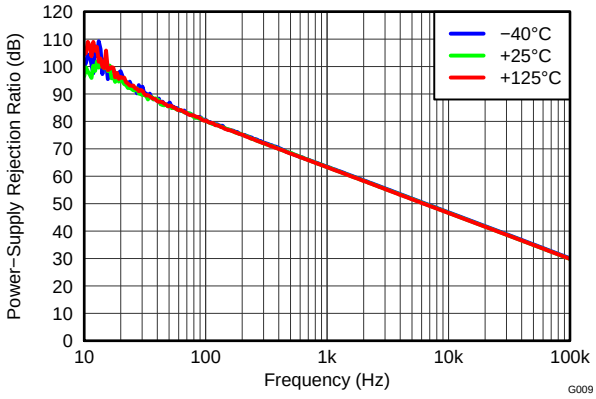


Figure 17.

NEGATIVE PSRR vs FREQUENCY

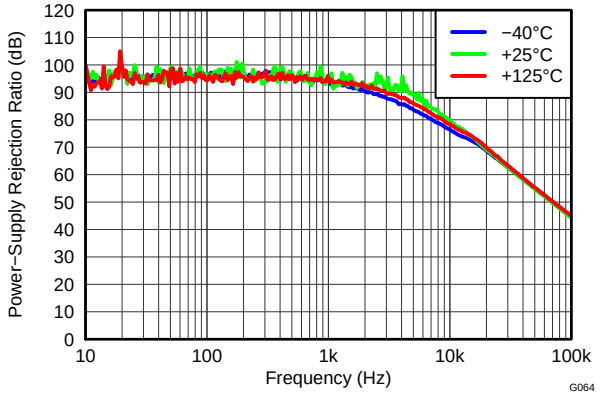


Figure 18.

MAXIMUM POWER DISSIPATION vs TEMPERATURE

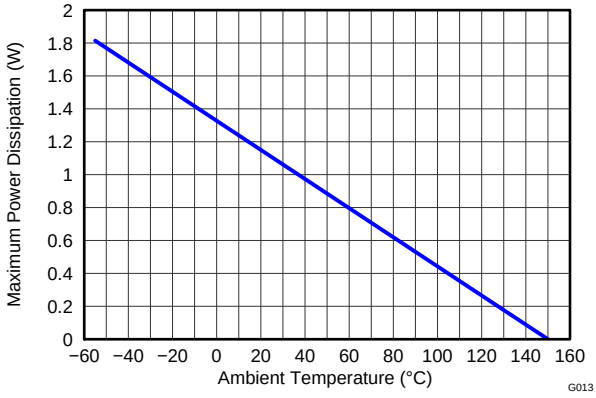


Figure 19.

TYPICAL CHARACTERISTICS (continued)

At T_A = +25°C, R_L = 2 kΩ connected to ground, and V_S = ±15 V, unless otherwise noted.

LARGE-SIGNAL STEP RESPONSE

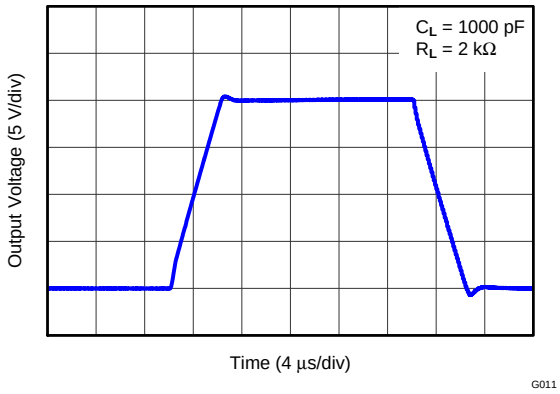


Figure 20.

SMALL-SIGNAL STEP RESPONSE

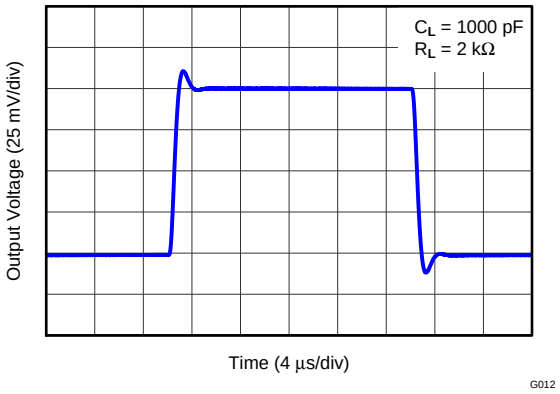


Figure 21.

SMALL-SIGNAL RESPONSE vs CAPACITIVE LOAD

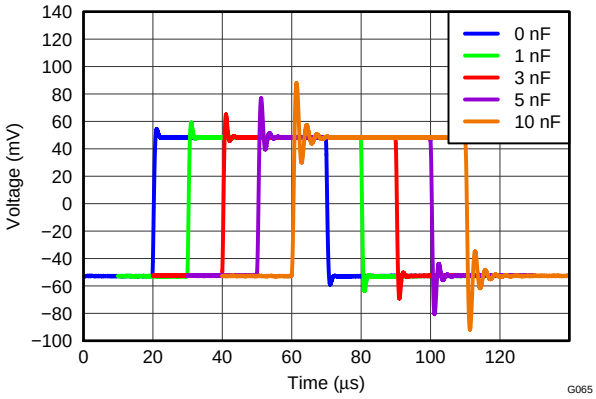


Figure 22.

SETTLING TIME

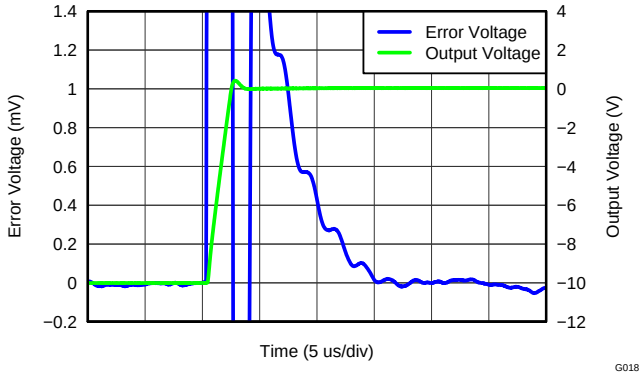


Figure 23.

SETTLING TIME

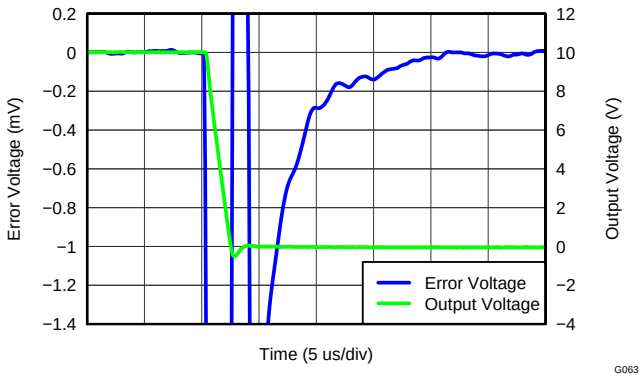


Figure 24.

CMRR HISTOGRAM

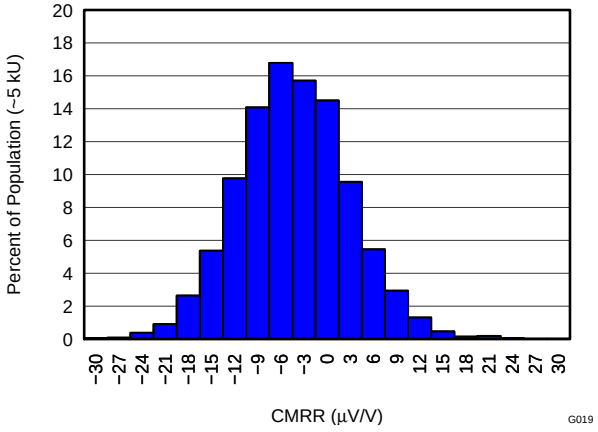


Figure 25.

TYPICAL CHARACTERISTICS (continued)

At T_A = +25°C, R_L = 2 kΩ connected to ground, and V_S = ±15 V, unless otherwise noted.

OFFSET VOLTAGE HISTOGRAM

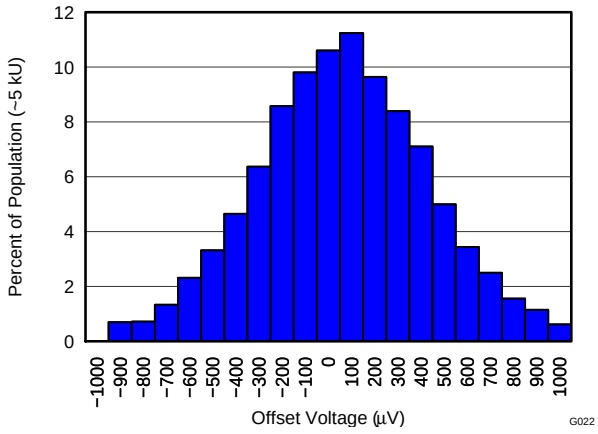


Figure 26.

DIFFERENTIAL GAIN ERROR HISTOGRAM

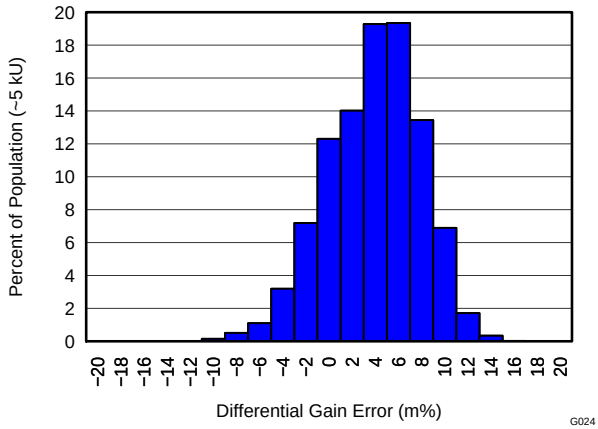


Figure 27.

PSRR HISTOGRAM

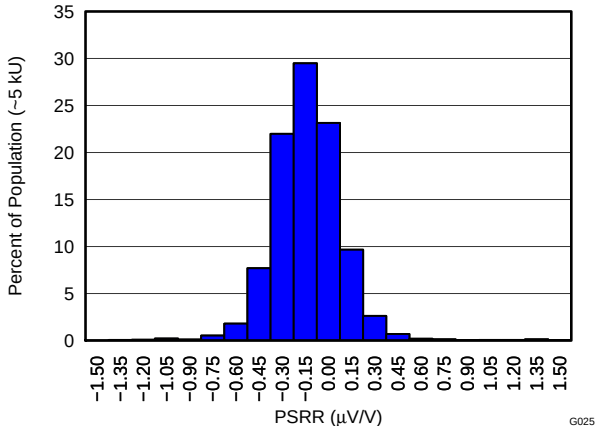


Figure 28.

GAIN NONLINEARITY HISTOGRAM

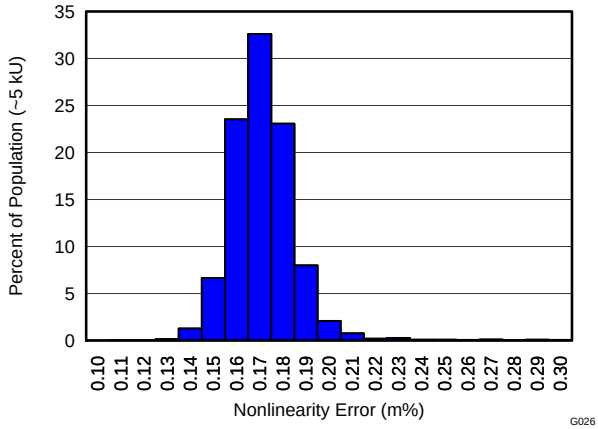


Figure 29.

OFFSET VOLTAGE vs TEMPERATURE

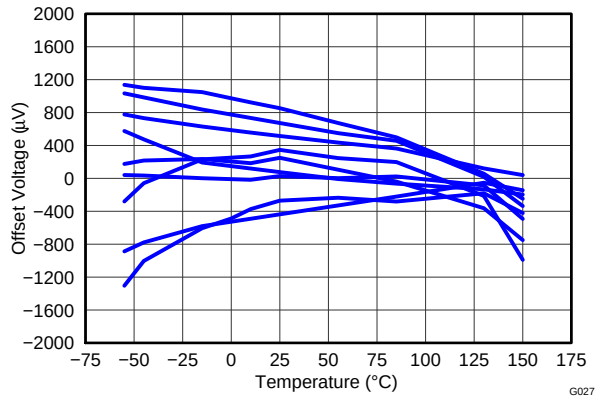


Figure 30.

CMRR vs TEMPERATURE

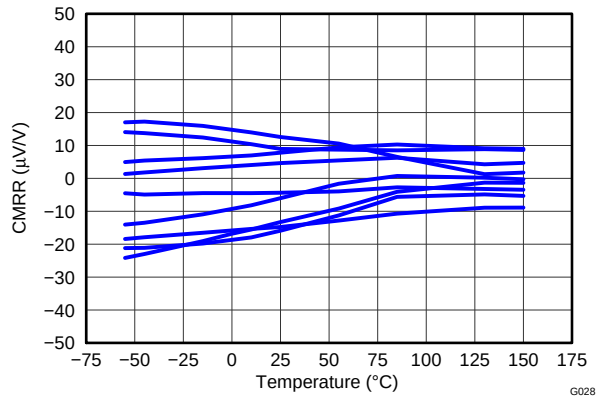


Figure 31.

TYPICAL CHARACTERISTICS (continued)

At T_A = +25°C, R_L = 2 kΩ connected to ground, and V_S = ±15 V, unless otherwise noted.

PSRR vs TEMPERATURE

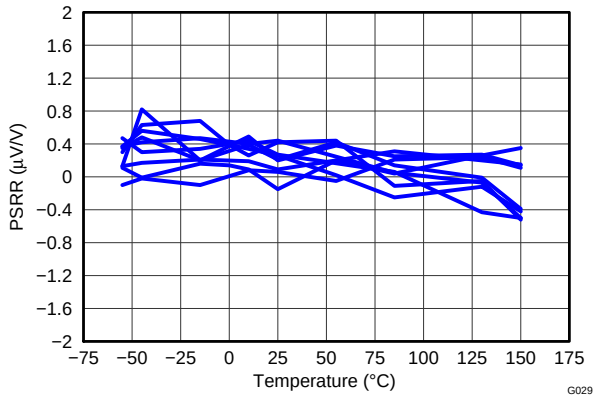


Figure 32.

GAIN ERROR vs TEMPERATURE

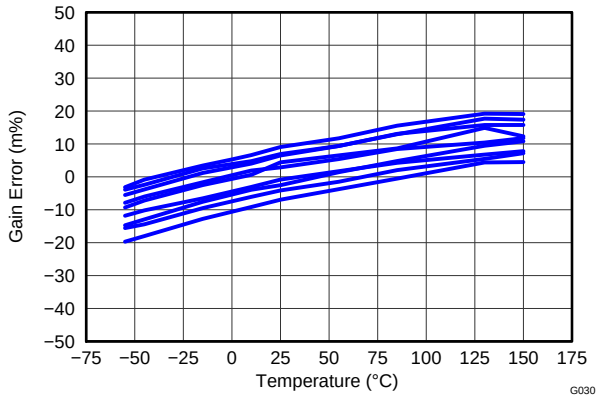


Figure 33.

GAIN NONLINEARITY vs TEMPERATURE

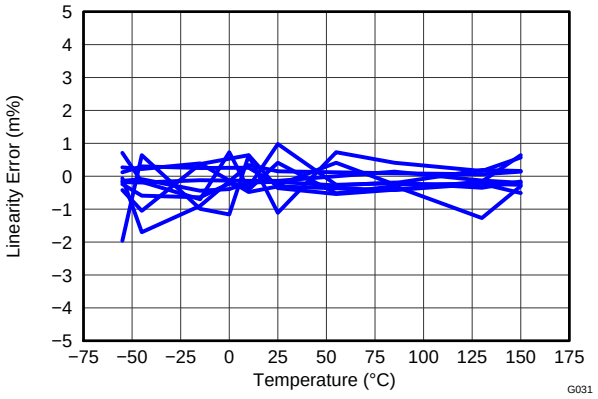


Figure 34.

SLEW RATE vs TEMPERATURE

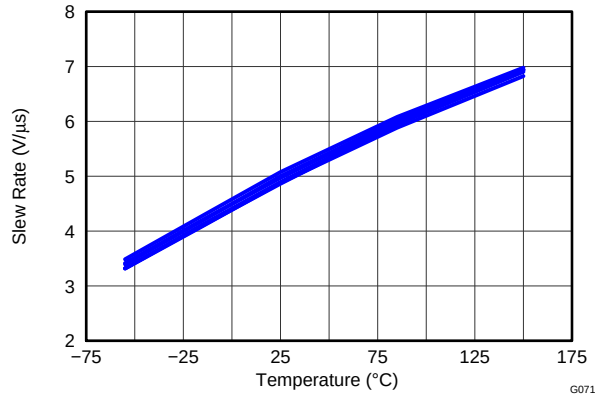


Figure 35.

SLEW RATE vs POWER-SUPPLY VOLTAGE

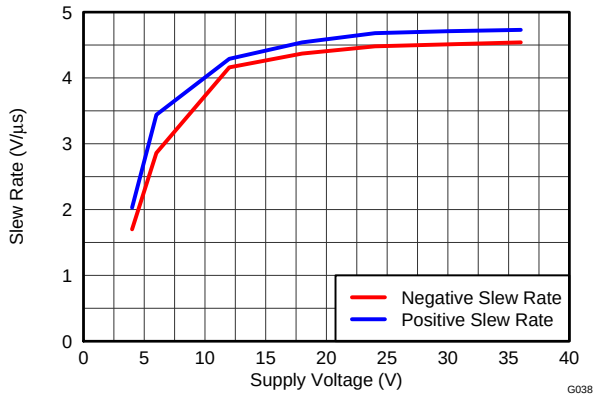


Figure 36.

QUIESCENT CURRENT vs TEMPERAUTRE

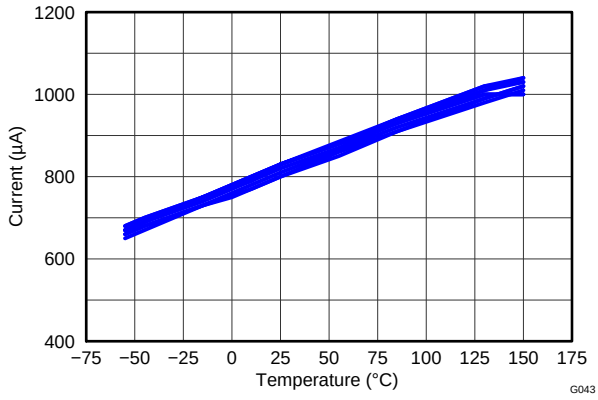


Figure 37.

TYPICAL CHARACTERISTICS (continued)

At T_A = +25°C, R_L = 2 kΩ connected to ground, and V_S = ±15 V, unless otherwise noted.

FREQUENCY RESPONSE vs CAPACITIVE LOAD

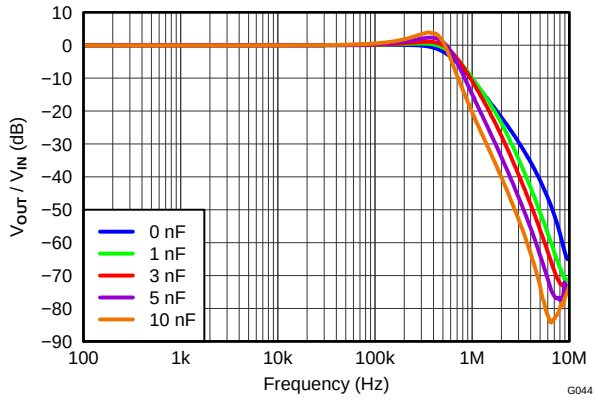


Figure 38.

QUIESCENT CURRENT vs SUPPLY VOLTAGE

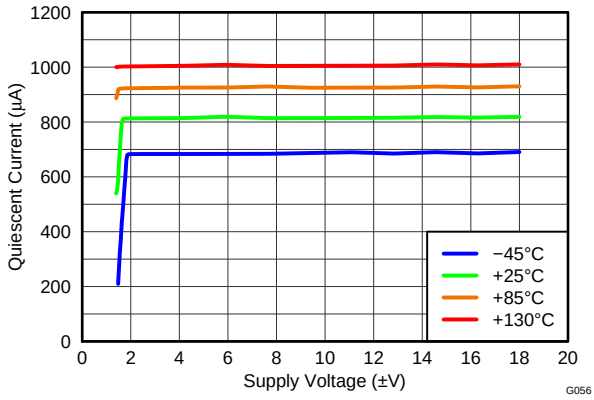


Figure 39.

MAXIMUM OUTPUT VOLTAGE vs FREQUENCY

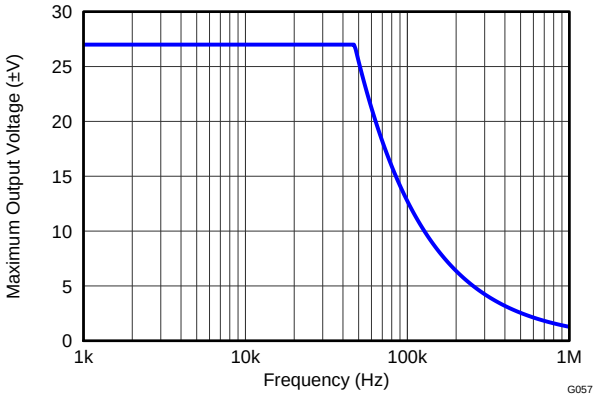


Figure 40.

OVERLOAD RECOVERY

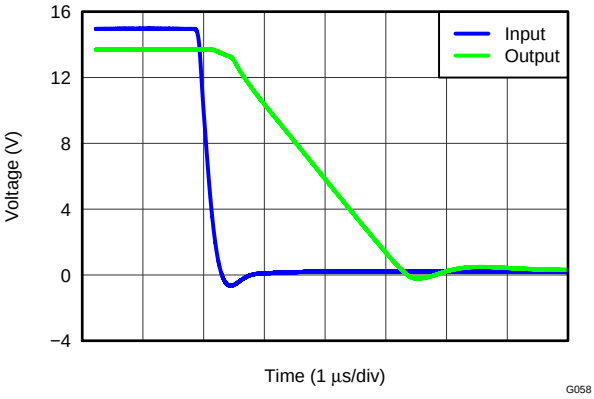


Figure 41.

OVERLOAD RECOVERY

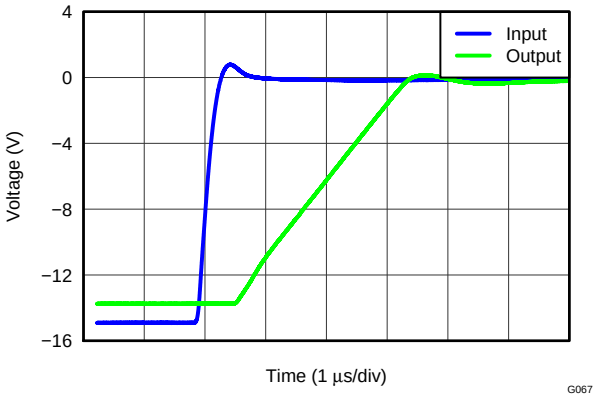


Figure 42.

QUIESCENT CURRENT HISTOGRAM

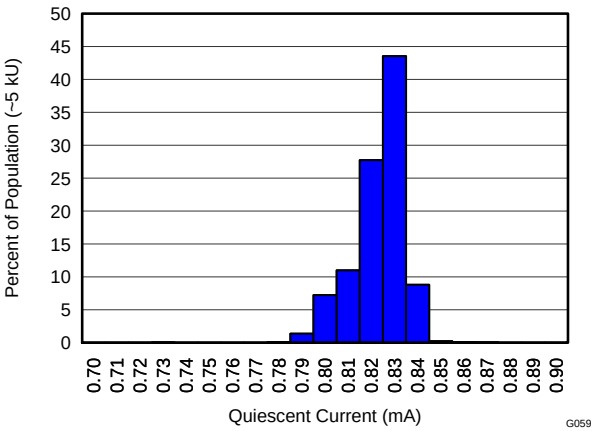


Figure 43.

APPLICATION INFORMATION

BASIC INFORMATION

Figure 44 shows the basic connections required for dual-supply operation. Applications with noisy or high-impedance power-supply lines may require decoupling capacitors placed close to the device pins. The output voltage is equal to the differential input voltage between pins 2 and 3. The common-mode input voltage is rejected. Figure 45 shows the basic connections required for single-supply operation.

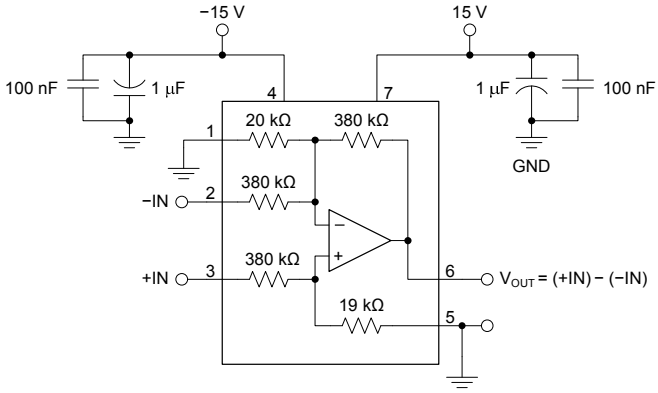


Figure 44. Basic Power and Signal Connections for Dual-Supply Operation

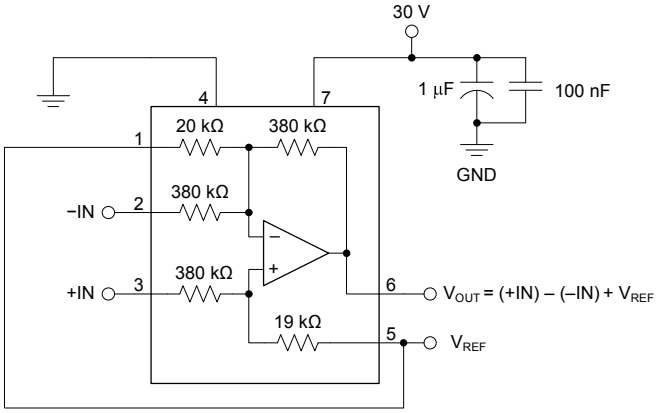


Figure 45. Basic Power and Signal Connections for Single-Supply Operation

TRANSFER FUNCTION

Most applications use the INA149 as a simple unity-gain difference amplifier. The transfer function is given in Equation 1:

$$V_{OUT} = (+IN) – (–IN) \quad (1)$$

Some applications, however, apply voltages to the reference terminals (REF_A and REF_B). The complete transfer function is given in Equation 2:

$$V_{OUT} = (+IN) – (–IN) + 20 \times REF_A – 19 \times REF_B \quad (2)$$

COMMON-MODE RANGE

The high common-mode range of the INA149 is achieved by dividing down the input signal with a high precision resistor divider. This resistor divider brings both the positive input and the negative input within the input range of the internal operational amplifier. This input range depends on the supply voltage of the INA149.

Both Figure 3 and Figure 4 can be used to determine the maximum common-mode range for a specific supply voltage. The maximum common-mode range can also be calculated by ensuring that both the positive and the negative input of the internal amplifier are within 1.5 V of the supply voltage.

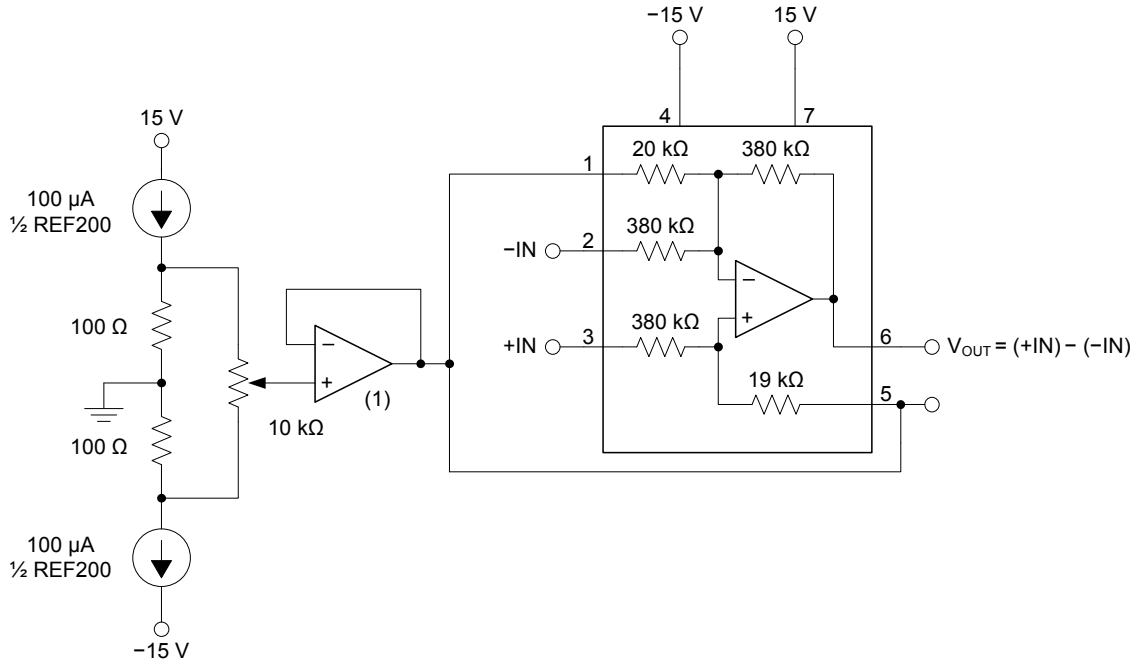
In case the voltage at the inputs of the internal amplifier exceeds the supply voltage, the internal ESD diodes start conducting current. This current must be limited to 10 mA to make sure not to exceed the absolute maximum ratings for the device.

COMMON-MODE REJECTION

Common-mode rejection (CMR) of the INA149 depends on the input resistor network, which is laser-trimmed for accurate ratio matching. To maintain high CMR, it is important to have low source impedance driving the two inputs. A 75-Ω resistance in series with pins 2 or 3 decreases the common-mode rejection ratio (CMRR) from 100 dB (typical) to 74 dB.

Resistance in series with the reference pins also degrades CMR. A 4-Ω resistance in series with pins 1 or 5 decreases CMRR from 100 dB to 74 dB.

Most applications do not require trimming. Figure 46 shows an optional circuit that may be used for trimming offset voltage and common-mode rejection.



(1) The OPA171 (a 36-V, low-power, RRO, general-purpose operational amplifier) can be used for this application.

Figure 46. Offset Voltage Trim Circuit

MEASURING CURRENT

The INA149 can be used to measure a current by sensing the voltage drop across a series resistor, R_S. Figure 47 shows the INA149 used to measure the supply currents of a device under test.

The sense resistor imbalances the input resistor matching of the INA149, thus degrading its CMR. Also, the input impedance of the INA149 loads R_S, causing gain error in the voltage-to-current conversion. Both of these errors can be easily corrected.

The CMR error can be corrected with the addition of a compensation resistor (R_C), equal to the value of R_S, as shown in Figure 47. If R_S is less than 5 Ω, degradation in the CMR is negligible and R_C can be omitted. If R_S is larger than approximately 1 kΩ, trimming R_C may be required to achive greater than 84-dB CMR. This error is caused by the INA149 input impedance mismatch.

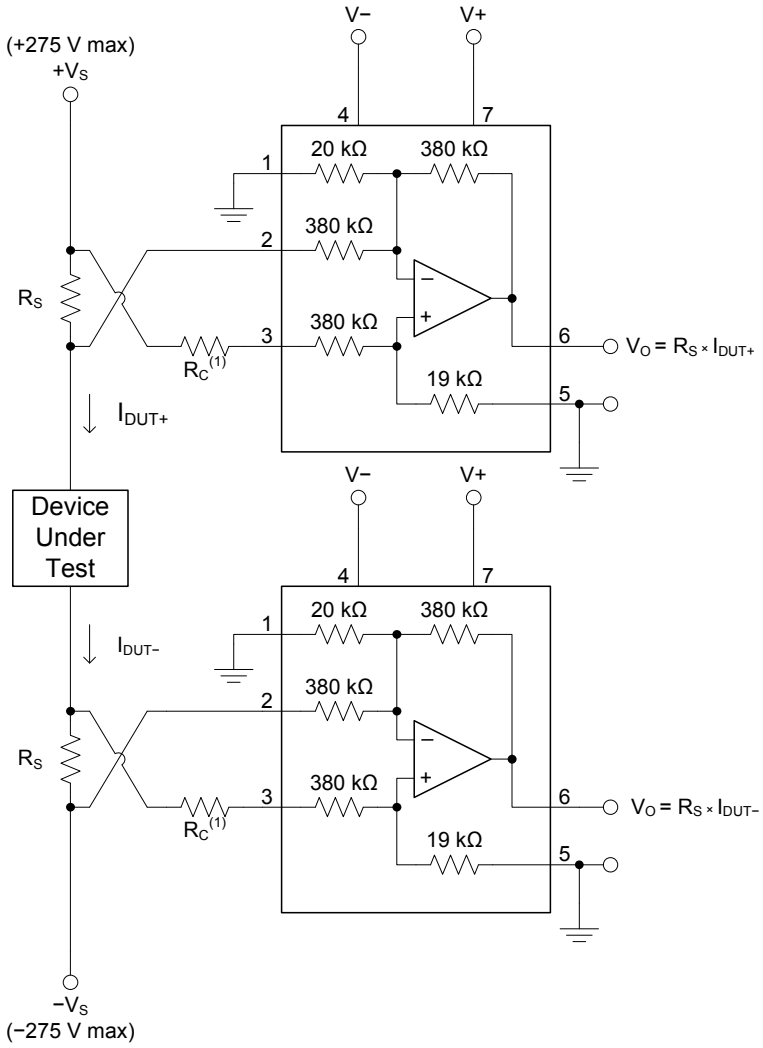


Figure 47. Measuring Supply Currents of a Device Under Test

If R_S is more than approximately 50 Ω, the gain error is greater than the 0.02% specification of the INA149. This gain error can be corrected by slightly increasing the value of R_S. The corrected value (R_S') can be calculated by

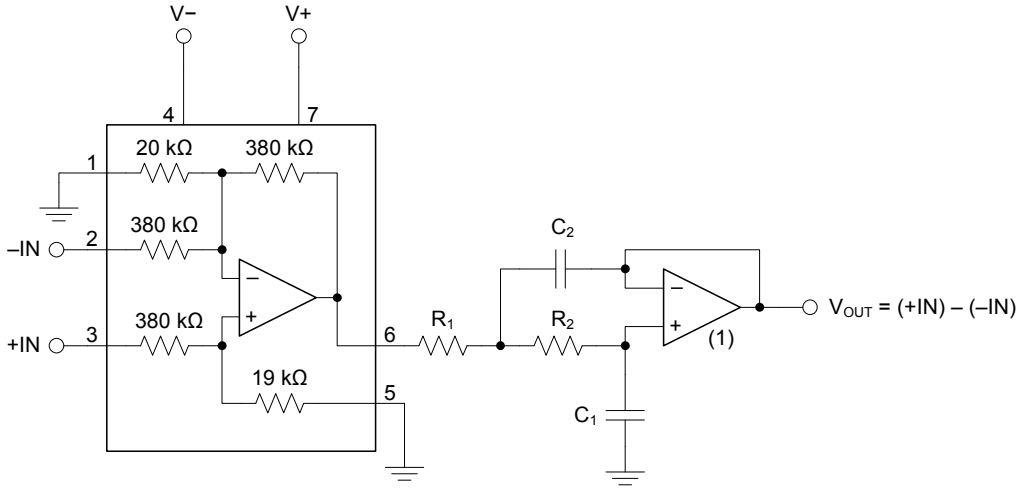
$$R_S' = R_S \times 380\ k\Omega/(380\ k\Omega - R_S) \quad (3)$$

NOISE PERFORMANCE

The wideband noise performane of the INA149 is dominated by the internal resistor network. The thermal or *Johnson noise* of these resistors measures approximately 550 nV/√Hz. The internal op amp contributes virtually no excess noise at frequencies above 100 Hz.

Many applications may be satisfied with less than the full 500-kHz bandwidth of the INA149. In these cases, the noise can be reduced with a low-pass filter on the output. The two-pole filter shown in Figure 48 limits bandwidth and reduces noise. Because the INA149 has a 1/f noise corner frequency of approximately 100 Hz, a cutoff frequency below 100 Hz does not further reduce noise.

Component values for different filter frequencies are shown in Table 1.



(1) For most applications, the OPA171 can be used as an operational amplifier. For directly driving successive-approximation register (SAR) data converters, the OPA140 is a good choice.

Figure 48. Output Filter for Noise Reduction

Table 1. Components Values for Different Filter Bandwidths

BUTTERWORTH LOW-PASS ($f_{-3\ dB}$)	OUTPUT NOISE (mV_{PP})	R_1	R_2	C_1	C_2
200 kHz	1.8	No filter			
100 kHz	1.1	11 kΩ	11.3 kΩ	100 pF	200 pF
10 kHz	0.35	11 kΩ	11.3 kΩ	1 nF	2 nF
1 kHz	0.11	11 kΩ	11.3 kΩ	10 nF	20 nF
100 Hz	0.05	11 kΩ	11.3 kΩ	0.1 µF	0.2 µF

BATTERY CELL VOLTAGE MONITOR

The INA149 can be used to measure the voltages of single cells in a stacked battery pack. Figure 49 shows an examples for such an application.

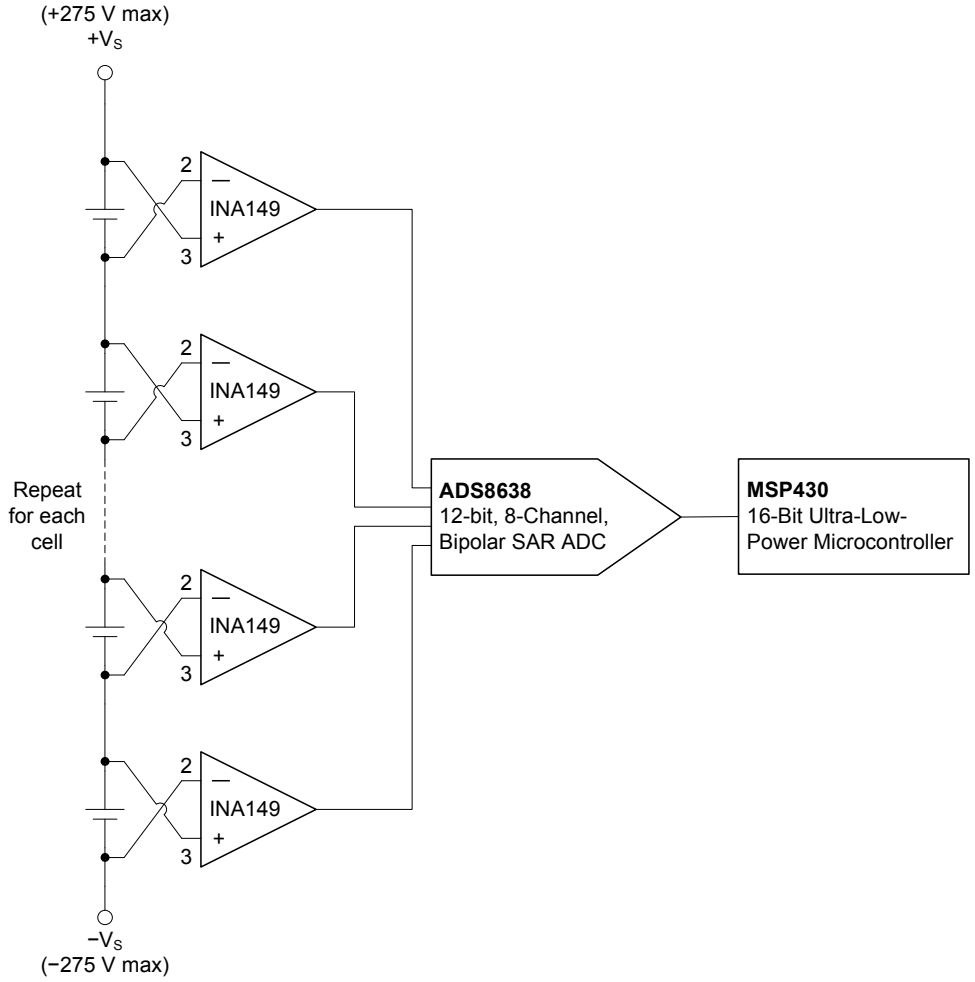


Figure 49. Battery Cell Voltage Monitor

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
INA149AMDREP	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-55 to 125	INA 149AM
V62/12614-01XE	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-55 to 125	INA 149AM

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

OTHER QUALIFIED VERSIONS OF INA149-EP :

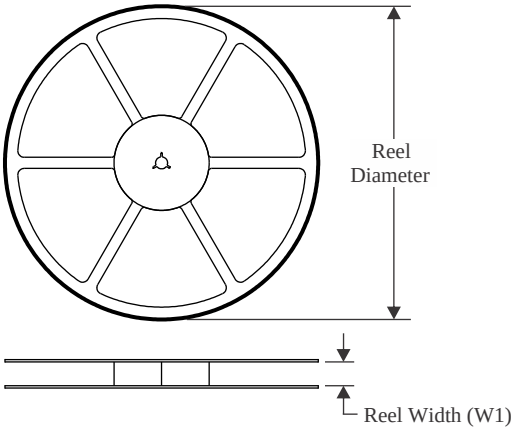
- Catalog : INA149

NOTE: Qualified Version Definitions:

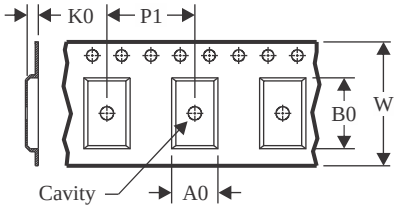
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

REEL DIMENSIONS

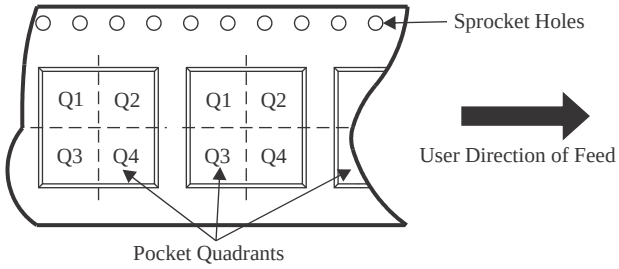


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

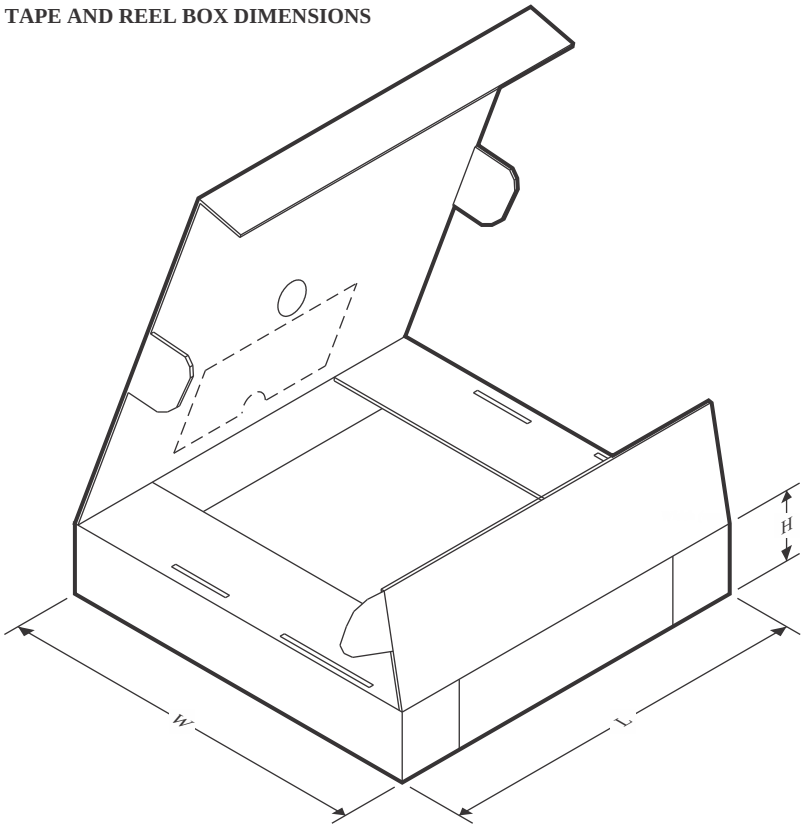
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

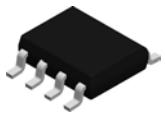
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
INA149AMDREP	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA149AMDREP	SOIC	D	8	2500	353.0	353.0	32.0

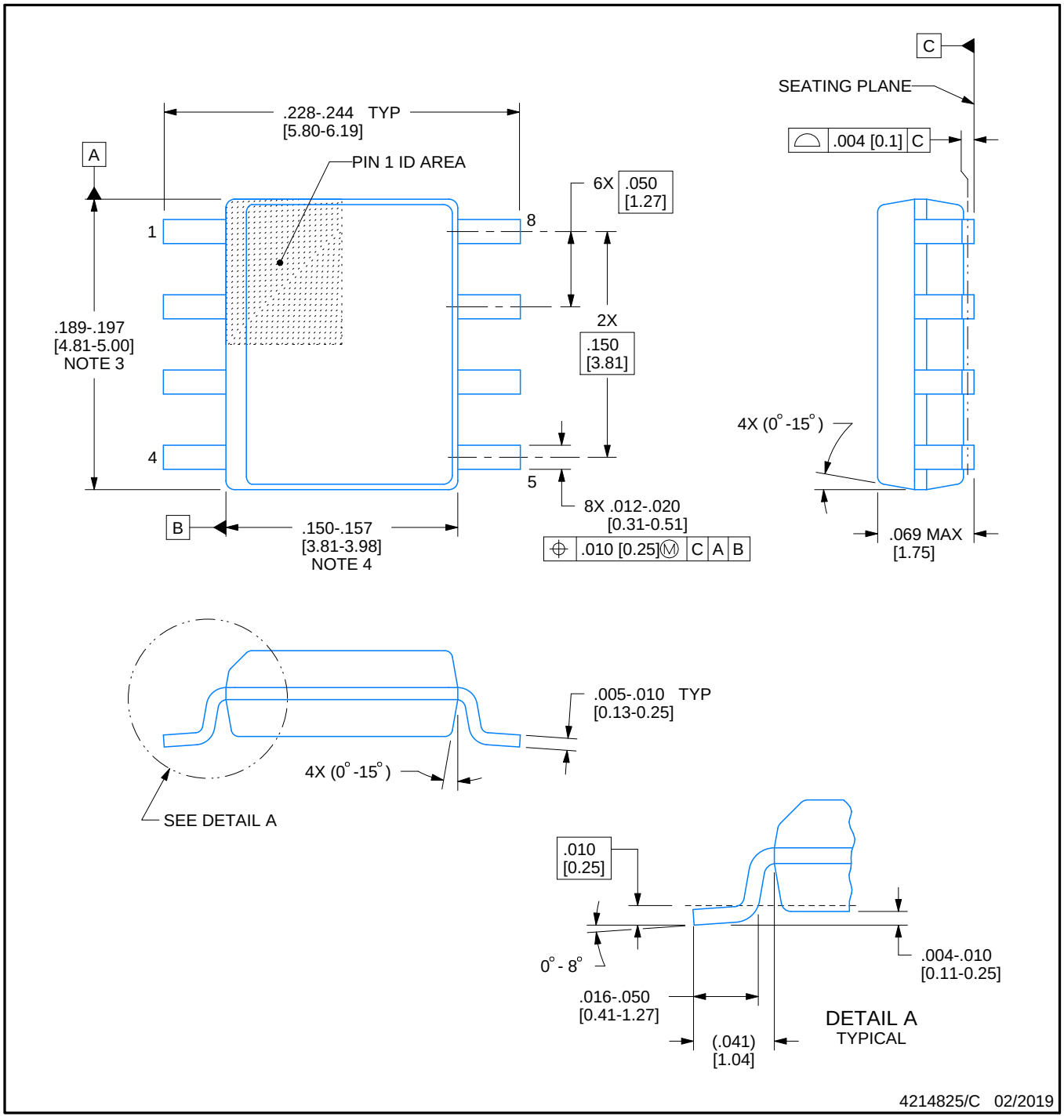


PACKAGE OUTLINE

D0008A

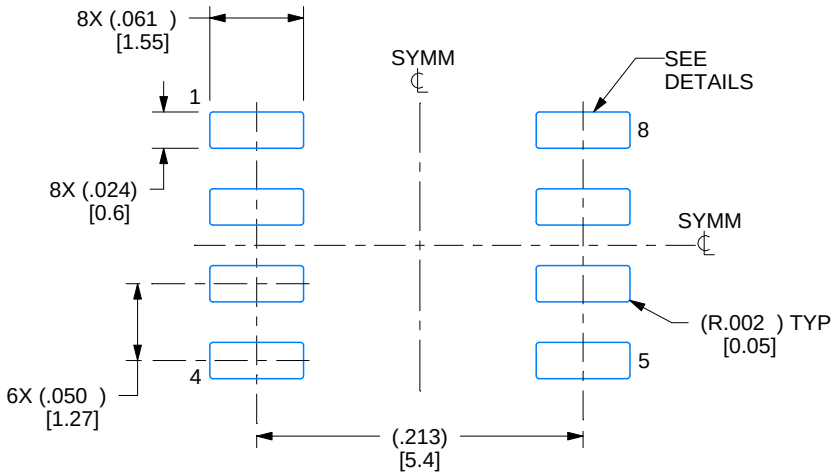
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

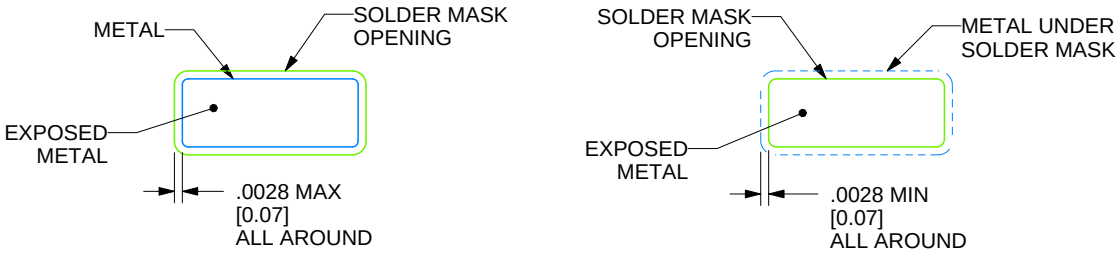


NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

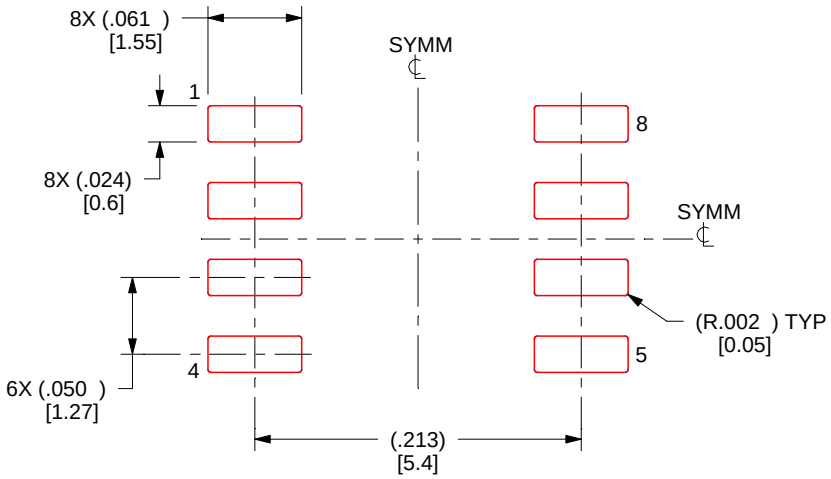
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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